Structural Organization of Life

The Discovery of Cell and Cell Theory:

Discovery of Cell

In 1665, an English biologist Robert Hooke invented first compound microscope and observed the sections of corks and leaves under this microscope. He noticed in them small box like chambers of same size which he called "cells". After this, biologists observed different organisms under the microscope. They found that structure of cells was complex.

Cell Theory

In 19th century, the compound microscope was highly advanced and biologists observed things just a micrometer apart. After this, a series of discoveries started, which provided basic information for cell theory.

1. In 1831 - 33, Robert Brown discovered nucleus in cells of plants.

2. In 1838, a German botanist Mathias Scheiden observed that all plants were made up of cells.

3. In 1839, Theoclor Schwann obsrved that the bodies of of animals were made up of cells which were similar to plant cells.

4. Thus, Schleiden and Schwann formulated the "Cell Theory". According to this, all organisms are made up of cells.

5. In 1840, J. Purkinji gave the name "Protoplasm" to the things found inside the cells. At that time, cell was considered as a bag of thick dense substance containing a nucleus.

Later on, resolving power and quality of microscopes were highly improved. Section cutting of tissues and cells and their staining became easier and better. It revealed that cell was not a simple mass of granular substance; instead it contained many sub cellular bodies called "Organelles". Each organelle has a definite job in the cell.

6. Human is made up of about 60 trillion cells. From Amoeba and unicellular algae to whales and tallest red wood trees, all' are made up of similar basic units called cell.s All animals and plants are thus made up of cells and cell products.

Salient Features of Cell Theory

1. All animals and plants are made up of cells and cell products. Among these some organisms are unicellular and some are multicellular.

2. Cell is structural and functional unit of living organisms.

3. New cells come from the divisions of pre-existing cell.

Electron Microscope:

Electron Microscope

This is the most advanced form of microscope. Its resolving power is 250 times or more that of a compound microscope. In this microscope, a beam of electrons under high voltage is passed through the object and its image is reflected on to a screen through an electro magnetic lens to make a photograph.

(Diagram)

With the help of microscope, any object an be magnified up to 250,000 its original size.

Comparison of Light Microscope and Electron Microscope:

Light Microscope

- The radiation source is light so it is called light microscope.
- Wavelength of light is 400 - 700 nm.
- Maximum resolution is 200 nm.
- Maximum useful magnification is X 1500 with eye.
- Lenses are used.

Electron Microscope

- The radiation source is beam of electrons, so it is called Electron Microscope.
- Wavelength of beam of electrons is 0.005 nm.
- Maximum resolution is 0.5 nm.
- Maximum useful magnification is X. 250,000 on screen as image or photograph.
- Electromagnets are used.

Structure of Cell:

There are two types of cells:

1. Prokaryotic cell

2. Eukaryotic Cell

Prokaryotic cell lacks a membrane bound nucleus and membraned organelles e.g. bacterial cell while eukaryotic cell has a membrane bound nucleus and membraned organelles e.g. cells of plants and animals.

With the help of light microscope and electron microscope, a typical Eukaryotic cell shows the following structural details.

(Diagram)

1. Cell Wall

2. Cell Membrane

3. Nucleus

4. Cytoplasm

Cell Wall

It is the outer most boundary of plant cells. It is rigid and non-living. It is chemically composed of Cellulose. The cell wall of fungi is made up of Chitin. The walls of some cells are thick and walls of some cells are thin. For example, in plants, xylem vessel elements and tracheids (which

transport water and minerals) have thick walls whereas as parenchyma cells (which store water and food) have thin walls. The primary layer of cell wall is known as primary walls which are further strengthened by an additional layer called secondary wall especially in xylem vessels. Secondary wall is thicker than the primary wall. Electron microscope studies reveal that cellulose fibers in primary and secondary walls have a criss cross arrangement.

Functions

Cell wall provides a definite shape, rigidity, protection and support to plant cell.

Cell Membrane

It is a thin membrane which is also called Plasma membrane. It is present in cells of all plants and animals. It is outer most boundary of animal cell while in plant cells; it is present inner to cell wall. Both nucleus and cytoplasm are surrounded by cell membrane. According to fluid mosaic model, cell membrane is composed of two layers of lipids in which protein molecules are partially or completely embedded.

Functions

Cell membrane is selectively permeable membrane. It means that it allows some things to pass through easily while some not. Thus, it controls the movement of material inside or outside the cell.

Nucleus

It is most important and distinct part of the cell. It is present in center of the animal cell while in plant cell it is pushed on one side due to large central vacuole. It is also surrounded by a membrane which is called membrane. Under microscope, it to be doubled and nuclear electron appears porous.

1. The number of chromosomes is fixed for each species. This number is called diploid number (2n). E.g human's cell has 46 chromosomes, cell of Radish has 18 chromosomes, and cell of union has 16 chromosomes.

2. Chromosomes are composed of protein and DNA.

3. In the nucleolus (plural, Nucleoli) ribosomal RNA is formed which helps in the formation of ribosome.

Cytoplasm

It is viscous opaque substance. It is present between nuclear membrane and cell membrane. In a living cell, many types of organelle of different sizes and shapes are found. It contains many insoluble granules of storage substances. There are also present organic compounds like carbohydrates, proteins, lipids (fats), enzymes and inorganic compounds like water and salts.

Functions

Cytoplasm provides chemicals, site and environment for different biochemical reactions.

Organelles in Cytoplasm:

Mitochondria:

They re oval or rod like in shape. Their membrane is doubled. Outer membrane is smooth while inner membrane has enfolding in the mitochondrial matrix. These enfolding are called cristae. The cristae bear small rounded bodies which are called particles.

There are about one million elementary particles in one mitochondrian. They are involved in oxidative phosphorylation. They also have many respiratory enzymes.

Number of Mitochondria

Their number is different in different cells of different animals. In more active cells, their number is more than 1000 e.g. liver cell.s The cells of ear lobes have a few number of mitochondria.

Function

Mitochondria re very important organelles of Eukaryotic cell.s Many oxidation-reduction reaction occur in the mitochondria. As a result energy is produced. This energy is used by cell in various functions. This the reason that mitochondria are also called "Power house of cell".

Golgi Bodies:

They were discovered by Camillo Golgi. They consist of set of smooth, flattened sacs which are called cristernae. The cristemae are stacked over each other. Golgi bodies are in the form of network in some cells or meshwork or filamentous in other cells.

Function

Golgi bodies store the secretions, convert them into finished products and pack them at their margins into small rounded sacs called Golgi vesicles, which transport secretions outside the cell.

Endoplasmic Reticulum:

It is a network of tubules and cristemae extending throughout the cytoplasm from nuclear membrane to cell membrane.

Types of Endoplasmic Reticulum

Following are the two types of Endoplasmic Reticulum:

Smooth Endoplasmic Reticulum

It is also called non-granular endoplasmic reticulum because ribosomes are not attached on it.

Rough Endoplasmic Reticulum

It is also called granular endoplasmic reticulum because ribosomes are attached on it.

Functions

1. Smooth endoplasmic Reticulum plays a role in synthesis of lipids.

2. Rough endoplasmic reticulum plays an important role in synthesis of proteins. It also transports materials from one part of cell to other.

3. Endoplasmic reticulum provides support to the cell.

Ribosomes:

These are tiny granular structures. These re not bounded by any membrane. These are formed in the nucleolus nd re freely dispersed in cytoplasm or attached with endoplasmic reticulum.

Functions

Ribosome is involved in protein synthesis. It is the only organelle which is also found in Prokaryotic cell.

Plastids:

These are pigment containing organelles. These are found in plant cells. Many plastids have one or more than one pigments.

Types of Plastids

Plastids are of three types which are as follows:

Chloroplasts

These are mot important plastids. These re green in colour and found in green parts of plant. These contain chlorophyll which helps in photosynthesis. The study of ultra structure reveals that it is bounded by a double membrane.

Inside the chloroplast there is present a semifluid matrix called called stroma, which is made up of proteins and other chemicals. The inner membrane forms stacked membrane system which becomes suspended in the stroma. Each membrane stack is called granum (plural grana. The membranes of grana are the sites where photosynthesis occurs in the presence of sun light.

Functions

In chloroplasts, photosynthesis takes place and food is prepared for plant.

Chromoplasts:

These are second type of plastids. These are of various colours other than green. In plants, colours other than green are due to chromoplasts. These are present in the petals of the flowers and in the ripened fruit.

Functions

These help the plants in pollination. These impart various colours to petals and fruits.

Leucoplasts:

These are third type of plastids. These are colourless plastids. These are triangular tubular or of any other shape. These are found in food storage prts of the plant especially the roots and tubers.

Centriole:

In animal cells, two centrioles are present near the nucleus. There are hollow and cylindrical. Each centriole consists of nine triplets of microtubules.

Function

Centrioles help in spindle formation during division of animal cell. Spindle is composed of protein fibers which help the chromosomes to move. Centrioles are absent in cells of higher plants. In some cells, centrioles help in the formation of flagella or cillia.

Vacuole:

It is a fluid filled small sac which is bounded by a single membrane. In animal cells, these are comparatively smaller in size but many in number while in plant cells; there is a large central vacuole which is filled with water and salts.

Functions

In small organisms, extra water and wastes are excreted through contractile vacuoles, while food is digested in food vacuole. Increase in size of vacuole results in an increase in size of cell.

Difference between Prokaryotic Cell and Eukaryotic Cell:

Prokaryotic Cell

- The organisms made of prokaryotic cells are called prokaryotes e.g. bacteria and cyanobacteria.
- These cells lack a membrane bound nucleus. The hereditary material (DNA) is found in cytoplasm.
- These cells lack membrane bound organelles.
- Ribosomes are of small size in and freely scattered cytoplasm.

- Cellulose is absent in cell wall, rather it is made up of peptido-glycan or murein.
- These cells are simple and of smaller size (average diameter 0.5 - 10 nm)

Eukaryotic Cell

- The organisms mae of Eukaryotic cells are called Eukaryotes, e.g. animals, plants fungi and protists.
- These cells have a membrane bound nucleus; and hereditary material is found inside the nucleus.
- These cells have membrane bound organelles.
- Ribosomes are of large size and are present in endoplasmic reticulum free in cytoplasm.
- Cellulose is present in cell wall of plant cells. The cell wall of most of fungi is composed of chitin.
- These cells are complex and of larger size (Average diameter 10-100nm)

Mitosis:

It is that cell division in which the number of chromosomes in both daughter nuclei remains same as in parent nucleus.

(Diagram)

Events of Mitosis

Mitosis has the following phases:

1. Prophase

2. Metaphase

3. Anaphase

4. Telephase

5. Cytokinesis

Prophase

1. In this phase, coiling of chromosomes starts and their length decreases but diameter increases. It means that chromosomes become shorter and thicker, this process is called condensation.

2. Microtubules arrange to form a structure called spindle.

3. In animal cell, there are also present centrioles on both poles of spindle. From each centriole, small microtubules or fiber arise forming a star shaped aster.

4. Spindle fibers, centrioles and aster collectively form mitotic apparatus. In plants, this apparatus is made up of only spindle fibers as asters are absent in these cells.

5. Nuclear membrane is broken down. Nucleolus disappears and chromosomes scatter over the spindle fiber.

6. Each chromosome consists of two similar threads like structure called chromatids, these chromatids are united to each other by means of centromere.

Metaphase

1. The chromosomes arrange themselves on equator of the spindle to form an equatorial plate. In this condition, chromosomes become more visible.

2. The chromosomes are attached at their centromere to one spindle fiber from each pole.

Anaphase

1. First of all spindle fibers shrink and become short.

2. The centromere of each chromosome then divides and the two chromatids of each chromosome start separating. At this stage these are not called chromatids because these are no in united condition these are called chromosomes.

3. These chromosomes start moving slowly towards the opposite poles. In this way, one set of chromosomes moves towrds one pole while other towards the other pole.

Telophase

1. The chromosomes reach their poles.

2. The chromosomes uncoil and become less visible.

3. Nuclear membrane reforms and nucleolus appears too. Therefore two nuclei are formed. Each daughter nucleus has the same number of chromosomes as the parent cell.

Cytokinesis

The division of cytoplasm is called cytokinesis. It begins at the last stages of nuclear division. In plant cell, cytoplasm divides by formation of cell plate which is also called phragmoplast. It gradually extends outward and finally two daughter cells are separated.

In animals, cytoplasm divides by furrowing. During this, there occurs inward pinching of cell membrane resulting into two daughter cells. In mitosis, two daughter cells are formed from one parent cell which are identical to their parent cell.

Significance of Mitosis:

1. Mitosis occurs in all types of somatic cells.

2. Daughter cells formed as a result of mitosis have same number of chromosomes as that of parent cell. In this way, all cells of body of an organism have same number of chromosomes.

3. Zygote divides by mitosis to form embryo and after hatching or birth, mitosis continues up to maturity of an individual.

4. Mitosis also results in growth and repairing of damaged or worn out tissues.

5. Healing of wounds is also due to mitosis.

Meiosis:

It is that type of cell division in which cytoplasm and nucleus divides twice and as a result of this, four daughter cells are formed and chromosome number is reduced to half. It means that one diploid (2n) parent cell divides to form four haploid (n) daughter cells.

Meiosis consists of two sub divisions:

1. Meiosis I

2. Meiosis II

Meiosis I

It has following stages:

Prophase I

1. It is lengthy than prophase of mitosis. It is very important phase. It is divided into five stages during which there is continuous condensation of chromosomes.

2. The important process of this phase is synapsis in which homologous chromosomes pair with each other length wise.

3. Each pair consists of four chromatids or two chromosomes.

4. After synapsis, the process of crossing over takes place. In this, homologous chromosomes exchange their chromatids parts at certain places.

5. At end of this phase, nuclear membrane breaks up. Nucleolus disappears and chromosomes scatter over the spindle.

6. Like mitosis, mitotic apparatus is also formed here.

(Diagram)

Metaphase I

1. The chromosomes arrange on scatter of the spindle.

2. Here, homologous bivalents arrange at equatorial plate of spindle.

3. Only one spindle fiber is attached to each chromosome.

Anaphase I

1. Homologous pairs of chromosomes are separated.

2. Spindle fibers contract.

3. Chromosomes begin to move towards the opposite poles.

4. This phase is different from metaphase of mitosis because half the number of chromosomes moves towards each pole and each chromosome still has two chromatids.

Telephase I

1. Half the number of chromosomes reach at opposite poles.

2. Chromosomes again increase their length.

3. Nucleolus reappears. Nuclear membrane is reformed and in this way two daughter nuclei are formed.

4. Now cytoplasm divides and two daughter cells are formed. Each cell is haploid (n).

Meiosis II

It is similar to mitosis. The haploid cells formed in meiosis I pass through phases of meiosis II and ultimately four haploid (n) daughter cells are formed. These cells afterwards change into spores (in plants or gametes (animals)

Significance of Meiosis

1. Meiosis takes place only in germ mother cells which form gametes or spores.

2. It maintains the chromosome number of a species constant generation after generation.

3. If gametes had the same number of chromosomes as in somatic cells, the number of chromosomes would have doubled after each generation in a species.

4. The number of chromosomes is constant for each species. During meiosis; gametes (both and) formed are haploid.

5. Gametes unite to form a diploid zygote.

6. During meiosis, pairing of chromosomes takes place which is called synapsis.

7. Exchange of genetic material occurs during meiosis. In this way variations are produced which are raw material for evolution.

Tissues:

A group of cells which perform same function is known as tissue. The tissues are divided into different types on the basis of their form and structure or function.

Plant Tissues:

Following are the types of tissues in plants:

1. Simple Tissues

2. Compound Tissues

Simple Tissues

Simple tissues consists of only one type of cells. In plants, they are of following types:

1. Meristematic or embryonic tissues

2. Permanent Tissues

Meristematic Tissues

1. Cells of this tissue have ability to divide.

2. Cytoplasm is dense nd nucleus is big in these cells.

3. Vacuoles are smaller if present other wise absent.

4. All cells are identical.

5. There are no intercellular spaces.

6. Their walls are thin and nucleus is present in centre of cell.

7. These tissues found on apex of root or shoot are called apical meristems. The cells of these tissues divide; and redivide to add primary tissue for elongation of setm or root.

This type of growth is called primary growth.

8. Meristematic cells are also found on the lateral sides of roots and stems as lateral(cambium) or intercalary meristem, and these add, secondary tissues. In this way, thickness of stem or root is increased. This type of growth is called secondary growth.

Permanent Tissues

The cells of this tissue lack the ability to divide and they originate from meristems. These are given below:

a. Epidermal Tissues

b. Ground Tissues

(a) Epidermal Tissues

1. They are found as the outermost covering of leaf, stem or root.

2. There are non intercellular spaces.

3. Cells are rectangular in shape.

4. In the epidermal tissues of stem and leaves, there are small openings called stomata for gaseous exchange.

(b) Ground Tissues

1. Most of the portion of body of herbaceous plants consists of ground tissues i.e. parenchyma.

2. They are thin walled.

3. Cells are large in size.

4. Cells sometimes may develop the ability to divide.

5. Their main functions are to prepare and store food and water.

Supporting or Mechanical Tissues

These provide strength flexibility to the plant. They are of following two types:

a. Collenchyma Tissues

b. Sclerenchyma Tissues

(a) Collenchyma Tissues

1. These consist of living cells.

2. Their walls are not uniformly thickened.

3. Usually walls are thickened at angles.

4. These are more flexible or elastic than sclerenchyma.

5. These tissues are found in stem, in midrib of leaves and in cortex of petiole.

(b) Sclerenchyma Tissues

1. These consist of dead cells.

2. Their walls are highly thickened due to deposition of lignin.

3. Lignin provides hardness and strength to the cell.

4. These cells are without protoplasm.

5. Sclerenchyma cells are of two types,

- Stone cells having uniformly thick cell walls; found in testa of seeds.
- Fibrous cells which are elongated cells found in xylem and phloem for strength and transport of water

Compound Tissues

These are the tissues which consists of two or more than two types of cells. But all cells perform a common function.

These Tissues are of following types:

Xylem Tissue

1. This vascular tissue transports water in the plants and provides strength to the plant.

2. In this tissue, there are present xylem parenchyma and two types of thick walled dead cells.

- Long cells which are called vessel elements or cells. They are joined together to form long pipe-lines. These transport water from roots to leaves.

- Spindle shaped cells, which are called tracheicts. These provide strength to root and shoot etc.

3. Xylem conducts water in one direction that is from roots towards the stem and leaves.

Phloem Tissues

1. This vascular tissue transports food in the plants.

2. It helps in two directional conduction of food material i.e. from leaves to roots and vice-versa.

3. This tissue mostly consists of living cells. There are three types of cells

(a) Phloem Parenchyma

(b) Sieve Tube Cells

(c) Companion Cells

(a) Phloem Parenchyma

These cells store surplus water and food. They can start to divide when needed.

(b) Sieve Tube Cells

Their end walls have small pores called sieve plates. These cells join to form long pipelines, which are called sieve tubes. There is no nucleus in these cells. Their main function is to transport food.

(c) Companion Cells

In some plants, each sieve tube cell is accompanied by a companion cell. The companion cell has a nucleus. The corn cell controls the movement of food through sieve tubes.

Animal Tissues

Following are four types of tissues that are found in animals:

1. Epithelial Tissues

2. Connective Tissues

3. Muscle Tissues

4. Nerve Tissues

Epithelial Tissues

1. these are found as outer most layers of an organ or as lining of body invaginations.

2. Their cells are long and flat.

3. These may form one or more layers of epithelial tissues of skin which is called squamous epithelial cells.

4. Squamous Epithelium provides protection to skin.

5. Some cells are cubical in shape and known as cuboidal epithelial cells.

6. Cuboidal epithelial cells from the lining of glandular ducts and help in the production of cell secretions.

7. Some cells are small and elongated which are found at certain places in the inner lining of different organs and secret juice. These are called columnar epithelial cells e.g. cells of gastric glands in stomach which secrete the gastric juice.

8. Some columnar cells have cilia at their free surface. These are called ciliated columnar epithelial cells e.g. cells present in trachea. Due to movement of these cilia, mucous and other materials are expelled.

Connective Tissues

1. This tissue is made up of semi fluid matrix.

2. These matrixes contain a variety of cells and fibers.

3. These tissues provide support to different body parts and bind them together. These also protect the organs from germs and help in the production of blood cells.

4. These are of two types:

- Soft connective tissues e.g. fatty tissues and tendons.
- Hard connective tissues e.g. cartilage and bone.

5. Blood is also a special connective tissue with cells suspended in the fluid medium. It transports materials in the body.

Muscular Tissues

1. This tissue is made up of special contractile cells or fibers.

2. The cells are elongated and are called muscle fibers.

3. These cells have the ability to contract and relax which results in movements of body and the organs.

4. Following are the three types of muscles in our body.

Skeletal Muscles

These are attached to cartilage and bones. These seem to be striped fibers under the microscope. Therefore these are striped or striated muscles. Their movements are under our control so these are voluntary muscles e.g. muscles of arm and legs which move these parts.

Smooth Muscles

These are found around hollow organs such as blood vessels, gut. These produce slow, sustained contractions but do not fatigue. These re composed of spindle shaped unstriated muscles. These are involuntary and are under the control of the autonomic nervous system.

Cardiac Muscles

These are found in the heart. These are composed of branched fibers and are capable of sustained contraction but do not not fatigue. These are also involuntary in action.

Nervous Tissues

1. These are composed of nerve cells which are called neurons.

2. Each neuron consists of a cell body, axon and dendrites.

3. These productive nerve impulse to conduct messages.

4. By this tissue, different body parts have coordination with each other.

5. This tissue also forms brain and spinal cord.

Unicellular Organism (Amoeba):

The organisms consisting of only one cell are called unicellular organisms e.g. Amoeba, Paramecium etc.

Ameoba

1. It is mostly found in fresh water pond or pool.

2. In the ponds, it is found moving about around the weeds and stones. Some species are found in the moist soil.

3. Amoeba is a large protist.

4. It does not have the permanent shape.

5. Its size is about the end of pin or it measures about 0.25mm. Therefore it is observed under the microscope.

6. Its structure is very simple.

7. It consists of nucleus and cytoplasm, which are surrounded by a cell membrane.

8. Cell membrane protects it.

9. Cytoplasm is divided into two parts. Outer clear and transparent part is called ectoplasm while the inner, viscous, translucent and granular part is called endplasm.

10. Endoplasm contains food vacuoles of different sizes. These food vacuoles help in the digestion of food.

11. The food of Amoeba consists of microbes present in the water of pond.

12. Contractile vacuole maintains the concentration of water in the body. It removes surplus water out of the cell.

13. In Amoeba, the exchange of gases and removal of waste.

14. In Amoeba, there are also present mitochondria, golgi bodies and ribosomes.

15. Nucleus changes its place with the movement of the organism.

Multicellular Organism:

The organisms consisting of many cells are called multicellular organism. e.g. Brassica Plant, frog, man etc. diagram?

Brassica Plant (Mustard Plant):

1. This plant is sown in winter and at the end of season, it produces seeds and then dies.

2. This is an annual plant.

3. An oil is extracted from seeds of this plant which is known as mustard oil.

5. The scientific name of this plant is Brassica Campestris.

Non-Reproductive Parts or Vegetative Parts

These parts do not directly take part in sexual reproduction e.g. root, stem, branches and leaves.

Reproductive Parts

These parts directly take part in sexual reproduction e.g. flower, fruit and seed.

Root of Brassica:

The root is that part plant which is present inside the soil. It is produced from radical of seed. The first formed root is called Primary root. During its growth, it gives off secondary and tertiary root. Each root has a root cap at its tip or apex. Behind the root cap, root hairs are present which absorbs water and salts from the soil. Roots also anchor the plant firmly in the soil.

Internal Structure of Root of Brassica

When transverse section of root of Brassica is observed under the microscope, the following parts are very prominent.

Epidermis

It is outermost and protective layer. It is single celled. Some cells grow outward to form root hair.

Cortex

It is present inner to epidermis. It is made up of several layers of thin walled living cells (parenchyma cells). There are present intercellular spaces. These cells store food.

Endodermis

it is the innermost layer of cortex. There are no intercellular spaces. There are thickenings of special materials around the cell which check diffusion of water from xylem to cortex.

Pericycle

The layer present inner to endodermis is called pericycle. There are also no intercellular spaces. All the branches of roots arise from pericycle.

Vascular Bundles

Xylem is present in middle of root which extends to pericycle in the form of four rays and controls one way transport of water and salts. In between the xylem rays, phloem bundles are present which transport food in two directions.

Stem of Brassica:

The stem is that part of the plant which grows above ground. It arises from plumule of seed. It is herbaceous and branched. It bears leaves and flowers. The part of stem or its branch from where a leaf arises is called node. The part between two nodes is called internode. the important function of stem is the conduction of prepared food from leaves to other parts and that of water absorbed from roots to leaves. It supports leaves, flowers and fruits like a pillar. It keeps the leaves in such a position that they can get light to prepare food.

Internal Structure of Stem of Brassica

When transverse section of stem of Brassica is observed under the microscope, following parts are visible.

Epidermis

It is the outermost protective layer of stem. Outer to epidermis, there is layer of cutin which reduces loss of water from stem. The cells are compactly arranged and there are no intercellular spaces.

Cortex

It is inner to epidermis. It is made up of many layers of parenchyma and collenchyma tissues. The main function of cortex is storage of water and food.

Endodermis

It is innermost layer of cortex. It is not prominent in stem. It allows suitable quantity of waer to enter cortex from xylem.

Pericycle

It is in the form of bundles in between the endodermis and vascular bundles. It is composed of sclerenchyma cells. It forms bundle cap.

Vascular Bundles

In stem, vascular bundles are arranged in the form of ring. Vascular bundle consists of phloem and xylem. Phloem is towards outside and xylem is towards inside. Few layers of cambium are present between the xylem and phloem. Cambium causes increase in diameter of the stem with passage of time.

Medullary Rays

There are present few layers of thin walled living cells between every two layers. These are called medullary rays. The medullary rays connect the cortex with pith for the transport of food.

Pith

The central part of stem consists of living, rounded, thin walled parenchyma cells. This part is called pith. Here food is stored.

Leaf of Brassica:

1. Leaf is produced on node of stem or its branch.

2. Each leaf consists of two parts. The stalk of leaf is called petiole and upper broad part is called lamina.

3. Young leaves are without petiole and their margins are entire or smooth.

4. Lower leaves are large in size. These are also without petiole but there margins are wavy.

5. In the middle of leaf there is a thick midrib.

6. From midrib, arise veins of different thickness and form a network in leaf. This arrangement of veins is called reticulate venation.

7. Veins are composed of xylem and phloem.

8. The angle formed between stem and leaf is called axil. In this axil, buds are present which gwo and become branches.

9. The dorsal and ventral surfaces of leaves are different from each other. Such leaves are called bifacial leaves.

10. The main function of leaf is the preparation of food by process of photosynthesis.

Internal Structure of Leaf

When transverse section of leaf is observed under the microscope, following structure are visible.

Epidermis

This layer of cells covers both upper and lower surfaces of leaf. Upper layer is called upper epidermis and lower layer is called lower epidermis. There are more number of stomata in lower epidermis than upper epidermis. This results in less transpiration and CO_2 enters according to need. Each stomata consists of two guard cells, which are bean shaped, or kidney shaped. There is a pore between guard cells through which exchange of gases takes place and water vapours come out of leaves.

Mesophyll

The tissue present between upper and lower epidermis is called mesophyll. It consists of two parts.

Palisade Mesophyll

Uper part consists of elongated cells which hare lying vertical. These are double layered closely packed cells and are called Palisade Mesophyll.

Spongy Mesophyll

The lower part is sponge like and has more intercellular spaces. This is called spongy mesophyll.

Both types of cells have chloroplasts containing chlorophyll. So, photosynthesis takes place here. The function of mesophyll is to manufacture food for the plant.

Vascular Tissue

It consists of midrib and veins. The midrib is bundle. Upper part of midrib is xylem and lower part is phloem. Pericycle and endodermis surround this bundle. Besides this Lamina has other bundle which are called veins.

Flower of Brassica:

The flower is reproductive part. With the maturation of age, the plant bears yellowish flowers. Many flowers are arranged on a branch in a special way. This branch is called peduncle. This arrangement of flowers on the peduncle is called Inflorescence.

Parts of Flowers

Flower consists of a stalk and floral leaves. The stalk is called Pedicel. The upper part of pedicel is comparatively swollen and flattened. This is called thalamus. On the thalamus, floral leaves are arranged in four whorls.

The details of floral leaves is as follows:

Calyx

It is the outermost whorl of floral leaves. It consists of four sepals. On maturation, its colour changes to yellow. In young flowers sepals cover the inner parts of the flower. The main function of calyx is to protect inner parts of the flower.

Corolla

It is the second whorl of floral leaves. It consists of four free petals. Its yellow colour is conspicuous and can attract insects, honey bees and butterflies which help in pollination.

Androecium

It is the third whorl present inner to petals. It is the male reproductive part. It consists of six free stamens. These are arranged in two whorls, the outer whorl has two small stamens and inner whorl has four long stamens. Each stamen consists of two parts. Lower stalk is called filament. Upper swollen part is called anther, Inside anther, a large number of pollen grains are produced.

When anther matures, a longitudinal slit appears in its walls from which pollen grains escape. AT the base of filament, four nectaries are present. These nectaries secrete nectar. To get nectar, insects visit the flowers. In this way, pollen grains get attached to the bodies of insects and are transferred from one flower to the other. This process is called pollination.

Gynoecium

It is the inner most part of flower. It is female reproductive part. It consists of two carpels, which are fused. Each carpel has three parts. The basal swollen part is called ovary. The stalk like part above the ovary is called Style. The top of style is somewhat swollen and it is called Stigma. Overy contains many ovules. Ovules are ripened to form seeds while ovary is ripened to form fruit. The fruit of Brassica is called Siliqua.

Frog:

Frog is found in he water or near the water. It belongs to class Amphibia. it passes a specific part of life in water and remaining life on land. Its bilogical name is Rana Tigrina. It is a cold blooded animal i.e. blood temperature changes with that of the environment. At the start of winter, water is decreased and temperature is lowered, the frog lives buried in the mud to over come winter.

Coelom:

The body cavity of frog is called Coelom. It contains many organs which form different systems.

Digestive System of Frog:

This system consists of alimentary canal and accessory glands like liver and Pancreas.

Alimentary Canal

It is a coiled tube through which food passes. It consists of buccal cavity, pharynx, oesophagus, stomach and intestines.

Buccal Cavity and Pharynx

Mouth is present between upper and lower jaws. Upper jaw has a row of pointed maxillary teeth. Lower jaw lacks teeth. There is a pair of set of vomerine teeth on the roof of the buccal cavity. Frog does not chew the food with teeth. But teeth are used only to grasp the food. The old teeth are continuously replaced by the new teeth through its life. Near the vomerine teeth, internal nostrils are present on the roof of the buccal cavity. These open outwards into external nostrils. Behind them, two large bulges indicate the position of eyes. The tongue of frog is sticky. The

tongue is attached at anterior end of buccal cavity. The posterior end of tongue is free and bifid. the frog feeds on different insects. To capture its prey, it suddenly throws its tongue on to the prey, which sticks to the tongue and is brought to the buccal cavity, when the tongue is drawn back.

Near the maxillary joints, pair of opening of eustachian tubes are present. In male frog, there is also, present a pair of opening of vocal, sacs on the lateral side of floor of the buccal cavity which help the croaking. Buccal cavity narrows, posteriorly to form pharynx. The digestive system, respiratory system and ears are linked to pharynx. In posterior part of pharynx, there is another opening called Glottis. This leads to lungs through tachea. It closes at the time of digestion of food but remains open when animal is respiring.

Oesophagus, Stomach and Intestine

Pharynx leads into a small but wider tube called oesophagus or gullet. The oesophagus opens into the stomach. The anterior end of stomach is called Cardiac end while the posterior end is called Pyloric end. The walls of stomach are muscular and glandular.

The muscles of walls of stomach contract and relax, by which food is broken down into tiny pieces. The secretions of stomach have different enzymes which help in chemical digestion. In stomach, digestion of protein of food is started. After stomach, first part of intestine begins which is called duodenum. The ducts from liver and pancreas open into the duodenum. These ducts bring juices from these glands. The second part of intestine is Ilium are called Small intestine. The secretion of pancreas is called Pancreatic Juice. Pancreatic juice enters the bile duct by small duct. This juice digests the food and brings in such form which can be absorbed by the blood through intestine. Digested food is absorbed by illium and surplus water is absorbed by recturm. Remaining undigested food is expelled though cloacal aperture. A membrane keeps the intestine intact at a place and prevents strangulation of small intestine. This membrane is called mesentery.

Respiroatory System of Frog:

There are three methods of respiration in frog.

- Pulmonary Respiration
- Cutaneous respiration
- Buccal Respiration

Pulmonary Respiration

The exchange of gases through lungs is called pulmonary respiration. In this process, frog keeps its mouth closed. Air reaches buccal cavity through nostrils. Nostrils are closed floor of buccal cavity is raised; glottis opens, and air is pushed into the lungs. The intake of air is called inspiration. In frog, there is a pair of balloon shaped lungs. Each lung consists of small thin walled chambers called alveoli which greatly increase the surface area of the lungs. On each alveolus, there are many blood capillaries. When lungs are filled with air, then exchange of gases occurs between blood and air in lungs at the site of alveoli. During this, the exchange of gases occurs between blood and air present in buccal cavity. After this air is removed from the lungs. Frog uses its nostrils and floor of buccal cavity for inspiration and expiration.

Oxygen present in the air is dissolved in moisture present on lining of lungs. Then oxygen is diffused into the blood where it combines with hemoglobin to form oxyhaemoglobin. This oxygenated blood goes to all parts of the body by means of capillaries. Where oxygen separates from oxyhaemoglobin molecules and is absorbed by the cells. Carbon dioxide from cells comes out into the blood, which carries it to the lungs, and from here carbon dioxide is expelled.

Cutaneous Respiration

In frog, exchange of gases occurs through skin during hibernation and swimming. This is called cutaneous respiration. Skin is richly supplied with capillaries. Skin is moist. Oxygen diffuses through skin to capillaries and is carried by blood and CO2 diffuses back to blood from cells and is discharged out.

Circulatory System of Frog:

It consists of blood vascular and lymphatic systems.

Blood Vascular System

The blood vascular system of frog consists of following parts:

- Heart
- Arteries
- Veins
- Capillaries

Structure of Heart

Heart is conical organ. It is muscular. It has three chambers. It is present in the body cavity between the oesophagus and sternum. Like a pump, it contracts and is relaxes. As a result of this,

blood continuously circulates in the body. The heart is surrounded by a membrane which is called pericardial which protects the heart.

The three chambers of heart are as follows:

1. Right Atrium

2. Left Atrium

3. Ventricle

the two atria form the broader interior part of the heart. The right atrium is larger than left atrium. Both atria are thin walled. The posterior conical thick walled part of the heart is called ventricle. A broad vessel, which is called truncus artenosus, arises from dorsal side of the ventricle and then divides into two branches near the atria. A thin walled triangular sinus venosus opens into the right atrium. Some biologists consider truncus arteriosus and sinus venosus as chambers of the heart.

Function of Heart

- The chambers of the heart beat in a rhythmic way.
- First of all sinus venosus contracts. Then, the two atria contract. After this ventricle and finally truncus arteriosus is contracted.
- The deoxygenated blood from the whole body except lungs is carried to sinus venosus by two precavals and one post caval.
- Sinus, venosus opens into the right atrium through an opening.
- Oxygenated blood from the lungs is brought into the the left atrium by two pulmonary veins.
- Both the atria open into the ventricle and push their blood collectively into the ventricle by a common aperture, which is guarded by a valve.
- This valve maintains the unidirectional flow of blood in the heart and prevents the back flow of blood.
- In the middle of ventricle some mixing of oxygenated and deoxygenated blood takes place. On the two sides the blood remains unmixed due to rapid flow of blood.
- When ventricle contracts the blood goes to the truncus arteriosus through an aperture. This aperture controls the speed and direction of the blood by a spiral valve present at the start of truncus arteriosus.

Arterial System of Frog:

The blood vessels which carry the blood from heart to different parts of the body are called arteries. The system consisting of arteries is called arterial system.

It starts from truncus arteriosus. It is divided into two main branches each of which further divides to form three small branches.

Carotid Arch

It supplies blood to lower jaw, tongue, eye and brain.

Pulmocutaneous Arch

It carries blood to lungs and skin.

Systemic Arch

Right and left systemic arches joint posteriorly to form dorsal aorta. But prior to their union, each systemic arch gives out arteries supplying blood to vertebral column, oesophagus and fore limbs.

Dorsal Aorta

It runs along the vertebral column towards hind limbs. It gives off following branches.

Coeliacomesenteric Artery

It supplies blood to digestive system.

Renal Arteries

These supply blood to kidneys and general organs.

Posterior Mesenteric Artery

It supplies blood to rectum.

Illiac Arteries

These supply blood to hind limbs of their sides.

After reaching their specific organs, all the arteries divide and redivide to form capillaries. The walls of capillaries are very thin. Due to this reason, the exchange of materials take place between blood and tissues. The capillaries join to form venules. These venules join to form veins. Then these veins carry blood back to heart.

Venous System:

The blood vessels which bring the blood from different body parts, back into the heart are called veins. The system containing of veins is called Venous system.

Following are the major veins in frog.

Pulmonary Veins

Blood from right and left lungs goes to left atrium through pair of pulmonary veins. These have oxygenated blood.

Right and Left Precavals

Each precaval is formed by union of three veins which bring blood from tongue, lower jaw, head, shoulders, forelimbs and skin. Both veins open in sinus venosus. From here blood goes to right atrium.

Postcaval

It is formed by union of five or six pairs of renal veins from the kidney and the genital veins. While passing through the liver, it receives two hepatic veins. Then it enters the sinus venosus. Therefore, venous blood from different body parts enters the heart.

Renal Portal Vein

The veins which bring blood from the hind limbs and pelvic region combine to form Renal portal vein. The renal portal vein enters the kidney of its side and form capillaries. Blood from kidney goes to the post caval through renal veins. Post caval caries the blood to the heart.

Abdominal Vein

The Pelvic veins of two sides combine to form abdominal vein. Before entering the liver, it divides into branches. In liver, it is further divided to form capillaries. The blood from the liver is drained into post caval by hapatic veins of both sides.

Hepatic Portal Vein

The blood vessels (veins) bringing blood form various organs of digestive system (stomach, duodenum, illiums, rectum, pancreas and spleen etc) combine to form a large vein. This is known as hepatic portal vein. Near the liver a branch of abdominal vein combines with it. Then it enters the liver and divides and redivides to form capillaries. The, blood entering the liver through hepatic portal veins goes to the post caval by means of hepatic veins. The blood from post caval goes to heart through sinus venosus.

The blood coming back into the heart is of two types.

- Oxygenated blood which comes from lungs by pulmonary veins.
- Deoxygenated blood from all parts of the body enters sinus venosus through precavals and post caval and then enters the right atrium.

Lymphatic System of Frog:

In circulatory system, due to blood pressure, many components of blood plasma come out of the capillaries and fill the inter cellular spaces. These components are also in the form of fluid and called tissue fluid or interstitial fluid. Much of it reenters the capillaries and some of it enters the lymph vessels where it is known as lymph. The flow of lymph is unindirectional. Through lymph "vessels" lymph goes to big veins. Thus, lymph again enters the blood.

1. The lymph keeps the tissues wet.

2. The lymph helps in transport of various substances from blood to tissues and vice versa.

Excretory System of Frog:

In frog, waste materials are removed in different ways e.g. through skin, lungs, liver digestive system etc. But for removal of nitrogenous wastes, there are two kidneys. Kidneys are attached to dorsal wall of body cavity. These are present close to vertebral column in posterior part of body cavity. These are elongated and made up of urinary tubules. Urinary tubules combine to form collecting ducts which open into Ureter. The urine from kidneys comes into ureters after illustration. Both ureters which start from edges of kidneys open into the cloaca. From here, urine is excreted directly or stored in the urinary bladder, which on opening of cloacal aperture is expelled. The carbon dioxide and water are excreted through lungs and skin while through liver and digestive system; undigested food and some wastes are excreted.

Reproductive System of Male Frog:

The reproductive system of male frog consists of a pair of testes and reproductive ducts. Each testis is attached to kidney by means of a membrane. At anterior end of testis, there is present fat

body. Each testis is composed of small ducts called seminiferous tubules in which sperms are produced. Sperms enter the kidney via vesa efferentia. Sperms reach the cloaca through ureter. From here, these are dischaged in the water through cloacal aperture in this way, ureter in male frog does two jobs, one is removal of urine and other is removal of sexual material, so it is called urinogenital duct and the urinary system and genital system are collectively call urinogenital system.

Reproductive System of Female Frog:

The reproductive system of female frog consists of a pair of ovaries and reproductive ducts. Ovaries are present close to the kidneys. At their anterior ends, there are present fat bodies. Each ovary contains many follicles in which eggs (ova) are produced. During breeding season, ovaries are enlarged. Ova are released into the body cavity through the coelomic fluid, these enter the oviduct. The anterior part of oviduct is funnel like called oviducal funnel and reach the uterus. The uterus opens into the cloaca. At last, ova are discharge in the water through cloacal aperture. In water, union of sperm with egg results in formation of zygote. From zygotes, offsprings are formed and in this way continuity of race is ensured.

Nervous System of Frog:

It consists of three parts:

1. Central Nervous System

2. Peripheral Nervous System

3. Sympathetic Nervous System

Central Nervous System:

It consists of brain and spinal cord.

Brain

Brain is enclosed in protective layers and is located in cranium or brain case, which is major part of skull.

Brain is divided into three parts:

(a) Fore Brain

(b) Mid Brain

(C) Hind Brain

(a) Fore Brain

This is anterior part of brain. This is associated with sense of smell. It controls the secretion of many hormones. It also receives messages from internal and external environment of the body.

(b) Mid Brain

This is central part of brain. This is associated with eyes and vision.

(c) Hind Brain

This is the posterior part of brain. It controls and coordinates body movements and maintains balance of the body. It also controls respiration, circulation, taste and digestion.

Spinal Cord

The posterior part of the brain is continuous with spinal cord. It runs through the vertebral column. The spinal cord controls the movements of trunk region.

Peripheral Nervous System:

It consists of nerves. These nerves connect the central nervous system (CNS) with various parts of the body. Some nerves originate from brain. These are called cranial nerves other nerves originate from spinal cord. These are called spinal nerves. In frog, there are 10 pairs of cranial nerves and 9 or 10 pairs of spinal nerves.

Cranial

Basically, nerves are of three types:

Sensory Nerves

These take messages from sensory organs to CNS.

Motor Nerves

These take messages from CNS to glands and muscles.

Mixed Nerves

These do both above mentioned functions.

Cranial Nerves

In these nerves, first, second and eight pairs are sensory nerves which are associated with senses of smell, sight and hearing. Third, fourth and sixth pairs are motor nerves which carry message from brain to the eye. Nine and ten pairs are mixed nerves, which are supplied to jaw, face, tongue and heart.

Spinal Nerves

These are all mixed nerves. These control functions of different organs.

Ear of Frog:

The organ of hearing in frog is "Ear" like other vertebrates.

Structure of Ear of Frog

The ear of frog consists of following three parts.

1. External Ear

2. Middle Ear

3. Internal Ear

External Ear

External ear consists of a bone. The vibration is produced in external ear when sound waves strike with it.

Middle Ear

Middle Ear consists of a tympanic membrane. On the inner side of the membrane is a cavity known as tympanic cavity. The cavity contains small rod like bones called ossicles. The middle ear is connected to internal ear by a tube which is called Eustachian tube; it transfers the vibrations towards the internal ear.

Internal Ear

The internal ear is a very delicate organ. It consist of three semi circular canals. These canals are filled with a fluid and sensory cells are located at special places in these canals.

Function of Ear of Frog

When sound waves strike the tympanic membrane, it is set into vibration, this is in turn vibrates the internal ear and thus sound waves stimulate the hearing receptors in the inner ear. The internal ear, in addition to hearing also keeps the balance of the body.

Eye of Frog:

The frog has two eyes one on each side of the head. If we make vertical section of the eye, we find that the innermost layer of the ball is the sensory retina. The retina contains photoreceptor cells. Outside the retina is the choroid, which is richly supplied with blood capillaries supplying nutrients to the retina. The sclerotic is the hard, outer most layer of the eye. It provides shape to the eye ball. The anterior transparent part of the eye is called cornea. Behind the cornea is Iris. The Iris has a window called the pupil. Behind the pupil is the lens of the eye. The cornea, pupil and lens focus light on the retina. A watery fluid is present in between the cornea and lens. Similarly a jelly like fluid is present between the lens and retina, through which light passes before it strikes retina. Optic nerve takes the sensory messages from the eye to the brain.